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THE

SCIENTIFIC PROCEEDINGS

OF THE

ROYAL DUBLIN SOCIETY.

IMPERIAL BUREAU OF ENTOMOLOGY
15 OCT. 1931
INSTITUTE

Vol. 20, N.S., Nos. 8–12. SEPTEMBER, 1931.

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[*Authors alone are responsible for all opinions expressed in their Communications.*]

DUBLIN:

PUBLISHED BY THE ROYAL DUBLIN SOCIETY,

BALLSBRIDGE, DUBLIN.

HODGES, FIGGIS, AND CO.,

20 NASSAU STREET, DUBLIN.

WILLIAMS AND NORGATE,

38 GREAT ORMOND STREET, LONDON, W.C. 1.

1931.

Price Three Shillings.

Royal Dublin Society.

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No. 8.

AWARD OF THE BOYLE MEDAL

TO SIR JOHN PURSER GRIFFITH, M.A.I., M.INST.C.E., *Past-President, Inst. C. E.*, 1931.[1]

REPORT OF THE COMMITTEE OF SCIENCE AND ITS INDUSTRIAL APPLICATIONS.

SIR JOHN GRIFFITH was born in 1848. He was educated in Trinity College, Dublin, where he took his Licence in Civil Engineering in 1868, the Degree of B.A.I. not being instituted till 1873. He was a pupil of Dr. Bindon Blood Stoney, F.R.S., Engineer-in-Chief of the Dublin Port and Docks, 1868–1870. He went as Assistant to Alexander Tate, County Surveyor, Co. Antrim, in 1870, and returned to Dublin in 1871 as Assistant to Dr. Stoney. He became Chief Engineer of the Dublin Port and Docks in 1898, and retired in 1913. Since his retirement in 1913 he has been in private practice as a Consulting Engineer, and has devoted much of his valuable time and professional knowledge to the services of his profession and his country. He was President of the Institution of Civil Engineers of Ireland in 1887–1889, and of the Institution of Civil Engineers in 1919–20, and has contributed valuable papers to the Proceedings of both these bodies. The Institution of Civil Engineers awarded him the Mamby Premium in 1879, and selected him to give the James Forrest Lecture in 1916. He was elected Commissioner of Irish Lights in 1913, and Senator of the Irish Free State in 1922.

Sir John was a member of the Royal Commission on Canals and Waterways, 1906–1911. He was a staunch supporter of the reclamation of our large bog areas for agriculture and interested in the Leinster Carbonising Co., about 1909, which hoped to develop, on a large scale, the production of power from peat with recovery of by-products of tar, and of fertilisers. He has carried out at his own expense for many years Industrial Research into the economics of the Peat Resources of Ireland, and on his property at Ferbane is to be seen one of the most modern continental types of automatic peat-winning and sod-spreading plants. He was Chairman of the Irish Peat Committee in 1917–18,

[1] The Medal was awarded by the Council of the Royal Dublin Society on April 16th, 1931. The presentation was made at the Special Bi-Centenary Meeting of the Society on June 25th, 1931, when the Medal was handed to Sir John Griffith by the President, Professor J. Joly, SC.D., F.R.S., F.T.C.D.

Member of the Commission on the Water Power Resources of the United Kingdom in 1918, and Chairman of the Water Power Resources of Ireland Sub-Committee, 1919–21; in 1923 Sir John was nominated by the Permanent International Committee of the International Navigation Congress as General Reporter on the Utilization of Waterways for the Production of Power, and he reported in 1923.

He was a Member of the Viceregal Commission on Waterford Bridge, and of that on Portumna Bridge. He was Advising Engineer to the Government on Wicklow Harbour and Foreshore Works, and on Arklow Harbour.

He was knighted in 1911, and became Vice-President of the Royal Dublin Society in 1922. He is Honorary Professor of Harbour Engineering in Trinity College, Dublin, and received the Degree of M.A.I. *Hon. Causa* from the University of Dublin in 1914.

Besides many papers published in the Proceedings of the Institution of Civil Engineers and of the Institution of Civil Engineers of Ireland, he has published papers on the Western Harbours of Ireland, and on a proposed National Harbour in Galway Bay.

In 1923 he interested himself in the project for developing the hydro-electric possibilities of the River Liffey, and, having obtained Parliamentary Powers, handed over the whole scheme to the State, as the more ambitious Shannon Power Development had, for the time, rendered the development of the Liffey unnecessary.

His professional activities are wide-spread. He was a prominent member of the Commission which investigated the possibilities of utilizing the energy of the Severn Tides. He is at present advising on various problems of the first engineering magnitude in connection with the Mersey and the Humber.

Of the innumerable directions in which his wide and wise charity has led him to expend himself, his energy, and his means, he would not wish us to speak, and to most of those of us who have the honour of knowing him, some of these activities are known.

LIST OF PUBLICATIONS.

Papers published in the Proceedings of the Institution of Civil Engineers.

1. Improvement of the Bar of Dublin Harbour by Artificial Scour. (Awarded the Mamby Premium.) 1879
2. Development of Appliances for Handling Raw Materials and Merchandise at Ports and other Large Centres of Traffic. (James Forrest Lecture.) 1916
3. Presidential Address. 1919

PAPERS PUBLISHED IN THE PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

1. On the Wrought Iron Dock Gates of Dublin Graving Dock. 1877
2. On the Lowering and Widening of Essex Bridge. 1880
3. Single Balk Dams used in the Port of Dublin. 1880
4. Presidential Address. 1887
5. An Experimental Method of Determining the Proper Position of the Suspension Bars for Lifting Concrete Blocks of Large Size and Irregular Shape. 1887
6. Notes on Creosoting Wood Paving Sets. 1887
7. Standard Tests and Specifications. 1889
8. Port of Dublin. 1889
9. Portland Cement. 1893
10. Testing Appliances for Portland Cement. 1893
11. Report to the Council of the Institution of Civil Engineers of Ireland on the International Congress of Engineers, held in Chicago, July 31st to 5th August, 1893. 1893
12. Notes on Further Experiences in Creosoting at High Temperatures. 1894
13. Manganese Steel and some of its uses. 1895
14. The Twin Scherzer Bridge on the North Wall Quay. 1912
15. Discussion on the Report of the Board of Trade Sub-Committee on the Water Power Resources of Ireland. 1923

PAPERS ON WATER POWER DEVELOPMENT.

1. Water Power and Irish Industrial Development. Paper at the Dublin Technical Instruction Congress. 1921
2. Water Power Resources of Ireland. Lecture before the Royal Dublin Society. 1922
3. Liffey Scheme. 1923
4. Liffey Scheme (Financial Memorandum). 1923
5. Legends, Dates, and Events. 1924
6. Estimate of Water Available for Power Purposes in the Catchment Basin of the River Liffey. 1923
7. Notes on Siemens-Schuckert Shannon Power Scheme. 1925
8. Further Notes on Siemens-Schuckert Shannon Power Scheme. 1925
9. Electricity Supply Bill, 1927. Difference between original Shannon Scheme and Present Bill. 1927

No. 9.

A STUDY OF BACTERIA BELONGING TO THE SUB-GENUS *AEROBACTER.*

By M. GRIMES and A. J. HENNERTY,
Department of Dairy Bacteriology, University College, Cork.

[Read June 16. Published separately July 24, 1931.]

In the course of the routine bacteriological examination of butter in our laboratory, it is usual to inoculate one-tenth of a gram of butter into lactose broth and incubate at 37° C. for 48 hours. It is also customary to inoculate one-tenth of a gram of butter into two tubes of litmus milk and incubate at 21° C. and 37° C., so as to note the type of fermentation produced. It was noticed on several occasions that, while there was no development of gas in the lactose broth tube incubated at 37° C., nor gassy fermentation in the litmus milk tube inoculated at 37° C., the litmus milk tube inoculated at 21° C. showed a gassy fermentation. A little of the serum from some of these was streaked on Levine's Eosin-methylene-blue agar, and a typical Aerobacter growth obtained. From that period—now extending over eighteen months—whenever a bacteriological examination was made of butter or water, lactose broth tubes were incubated at both 37° C. and 21° C., and, particularly in the case of butters, there was, on several occasions, gas production at 21° C. when there was no gas production at 37° C. When this happened, the culture was streaked on Levine's Eosin-methylene-blue media, and in most cases a typical Aerobacter growth was produced. A collection was made of these cultures, and finally, after a preliminary comparison, seven were selected for full examination. The results are given in Tables 1, 2, and 3. Standard methods were used. Incubation temperature, 21° C., unless otherwise stated. It is to be remarked that in some cases where there was gas production at 21° C. there was little or only a faint growth when streaked on Levine's Eosin-methylene-blue agar, but these were discarded for lack of time to study them. Although most of the cultures examined were isolated from butter, they are considered to be soil types, which were probably introduced through the medium of the water used for washing the butter.

A study of Tables 1, 2, and 3 will show that cultures A, C, R, T, and W resemble one another—none of these cultures showed liquefaction when held for five weeks at 21° C. Culture R was originally chosen because it caused marked ropiness in milk, and this was found to be a permanent character. A and C later developed the property of causing ropiness in milk, but this property was not found to be a permanent character, and it was considered that the production of ropiness in milk could not be used in a system of classification. These strains differed in their ability to ferment inositol, and cultures T and G were found to ferment adonite. Cultures R, A, and C sometimes showed ropiness in the various sugar broths. This was found to be a variable character. Cultures T and W never produced ropiness. Culture R is taken as the type culture, and named *Aerobacter hibernicum.*

Cultures G and K differed from one another in that G fermented inulin, and did not ferment inositol. Culture K produced acid, but no gas in glycerine; culture G produced both acid and gas in glycerine. Both cultures liquefied gelatine, and there is considered sufficient data to show that they are not to be regarded as strains of *Aerobacter cloacae.* Culture K is taken as the type species, and named *Aerobacter liquefaciens.*

Cultures R, A, C, and K regularly produced gas in sugar broths at 21° C. and 30° C., but were never found to produce gas at 37° C., although the change in pH and direct microscopic examination showed bacterial growth. Culture G produced gas at 21° C. and 30° C. in sugar broths, and also in some of the sugar broths at 37° C. Cultures T and W produced acid and gas at 21° C., 30° C., and 37° C.

Cultures were examined for motility by inoculation into a special mineral salt solution, wihch was found to yield rapid growth of these cultures in 12 to 24 hours. This was the result of a number of experiments, and its composition is:—

Sodium chloride	0·5 g.
Ammonium chloride	0·5 „
Calcium nitrate	0·5 „
Magnesium sulphate	0·5 „
Potassium phosphate	1·0 „
Potassium acid phosphate ...	1·0 „
Glucose	5·0 „
Ferric chloride	trace.
Water	1000 c.c.

Adjust reaction to pH 7·0.

A study of Table 3 will show that where a sugar is not fermented, growth caused a change of pH to the alkaline side.

The production of gas in sugar broths was measured by inoculating the sugar broth contained in a test-tube which contained an inverted Durham tube.

While all the cultures did not show gas production by this method, the change of pH showed whether the sugar was fermented. It will be seen that while all the cultures fermented glycerine, as shown by change of pH, the gas production as shown by the Durham tube method varied with the different cultures. The glucoside salicin was fermented by all the cultures examined, while the alcohol dulcitol was not fermented, so that neither was of value for differentiation purposes.

It was noticed that motility was most marked at 21° C., variable at 30° C., and hard to determine at 37° C. The most actively motile bacteria were the smaller ones, 0·75μ to 0·9μ by 1·0μ to 1·25μ. As the size increased, they tended to become sluggish. At 37° C. most of the bacteria tended to be 1·0μ by 2·0μ.

Several attempts were made to determine the type of flagellation. All the listed methods were tried. It is considered from our experience that the best is Maneval's method, as given in the Journal of Bacteriology, May, 1931. The flagella were found to be peritrichous.

The thermal death point in lactose broth solution ranged from 62° C. to 70° C.

When the examination of the cultures was completed, difficulty was experienced in deciding whether one was dealing with new species or not. The chief help was obtained from the classifications of Levine (1), Weldin (2), Bergey (3), Weldin and Levine, and from personal communications from Professor Max Levine and Dean R. E. Buchanan. In checking the classifications, one felt the need for an International Body dealing with the nomenclature and classification of bacteria that would deal with the chief groups of bacteria in a series of monographs, bringing together the papers on each group in the different languages, and subjecting them to a critical investigation by the chief authorities in that group. This can be done, now that there is an International Committee to deal with nomenclature and classification, and that we have the type culture collections in England, Holland, Austria, and the United States. A differentiation should be made between listed species of which a type culture does not exist and listed species of which a type culture exists and is available for study. It is suggested that the second group be considered separately, and it would be of great value to research workers if there was available a publication or series of publications giving the list of existing type cultures, with a reprint of the published information concerning them. The listing of names of species of which there is no existing culture, and of which there is not sufficient data to enable a research worker in that group to determine whether a culture of his may be that culture or not, only causes confusion, and these should be put on a reserved list.

This investigation shows, that while it is now usual to carry out the test for the Escherichia-Aerobacter group in water and dairy products at 37° C., the test should also be carried out at 21° C., otherwise the Aerobacter group although present may not be identified.

AEROBACTER HIBERNICUM.

Morphology.

Rods, 1·0μ to 2·0μ × 0·75μ to 1·0μ. Aerobic, facultative, non-spore forming, gram negative, motile.

Cultural Characters at 21° C.

Nutrient Agar.—Five days — surface colonies — good rapid growth, circular, greyish, smooth, glistening, moist, slimy, opaque, convex, and entire.

Nutrient Agar Slant. — Two days — abundant, whitish-grey, raised, smooth, glistening, opaque, slimy. Edge rather definite.

Nutrient Gelatine. — Two days — Punctiform colonies, which did not liquefy gelatine.

Nutrient Gelatine Stab.—Filiform growth along line of stab — greyish surface growth around point of inoculation. No liquefaction in five weeks.

Levine Media.—Two days—abundant growth, typical of the Aerobacter group.

Potato Slope. — Ten days — abundant growth, dirty grey to pinkish brown—raised, spreading, smooth, glistening, moist, slimy, opaque.

Dunham's Solution.—Ten days—good growth—very turbid. Change of pH from 7·0 to 8·2.

Nutrient Broth.—Ten days—good growth, turbid.

Physiological Characters at 21° C.

Methyl red Test.—Negative.

Voges Proskauer Test.—Positive.

Uric Acid Media.—Two days — very turbid. Media changed from pH 6·8 to pH 6·0.

Citrate Media.—Two days—turbid. Media changed from pH 6·6 to pH 7·0.

Fermentation.—Ten days—acid and gas in sucrose, lactose, maltose, dextrose, levulose, galactose, arabinose, raffinose, crystal violet lactose, dextrine, salicin, mannitol, sorbitol, glycerol. Neither acid nor gas in inulin, dulcitol, adonitol. Inositol may or may not be fermented.

Plain Milk.—Acid—gas—coagulation and ropiness. Acidity after 4 days, ·52 per cent.; after 7 days, ·34 per cent.

Litmus Milk.—Acid—gas—coagulation and ropiness.

Nitrates.—Reduced.

Indol.—Negative.

Diastatic Action.—Negative.

Remarks.—Optimum temperature, 25° C.
Thermal death point, 66° C.

Culture R is taken as the type species; it constantly produced ropiness in milk, and produced acid and gas in inositol. Cultures A and C are regarded as strains; they sometimes caused ropiness in milk, but this property was found to be a variable character. Culture W is regarded as

a strain, although it never produced ropiness in milk, and produced 5 per cent. gas in 10 days in inositol. Culture T is regarded as a strain, although it produced acid and gas in adonite, and gave a porcelain-white raised surface growth around the point of inoculation in a nutrient gelatine stab.

AEROBACTER LIQUEFACIENS.

Morphology.

Rods, 1·0μ to 2·0μ × 0·75μ to 1·0μ. Aerobic, facultative, motile, non-spore forming, gram negative.

Cultural Characters at 21° C.

Nutrient Agar.—Five days — surface colonies — good rapid growth — circular, greyish, smooth, glistening, moist, slimy, opaque, convex, and entire.

Nutrient Agar Slant. — Two days — abundant growth, whitish grey — raised, spreading, glistening, with a somewhat slimy appearance, opaque, smooth.

Nutrient Gelatine.—Two days. Punctiform colonies, which liquefied gelatine. Liquefaction occurred in circular form round the colony itself, presenting the customary concave appearance.

Nutrient Gelatine Stab.—Three days—filiform growth, with slight liquefaction. Seven days—ten per cent. funnelform liquefaction. Twenty-one days—40 per cent. liquefaction.

"Levine Media."—Good growth—typical of the Aerobacter group.

Potato Slope.—Ten days—abundant growth—pinkish brown—raised, spreading, smooth, glistening, moist, slimy, opaque.

Dunham's Solution.—Ten days—good growth; marked turbidity. Very slight filamentous deposit at the bottom of test-tube. Change of pH from 7·0 to 8·2.

Nutrient Broth.—Ten days—good growth, turbid.

Physiological Characters at 21° C.

Methyl red.—Negative.

Voges Proskauer Test.—Positive.

Uric Acid Media.—Two days — very turbid. Media changed from pH 6·8 to pH 5·9.

Citrate Media.—Two days—marked turbidity. Media changed from pH 6·6 to pH 7·2.

Fermentation.—Ten days—acid and gas in sucrose, lactose, maltose, dextrose, levulose, galactose, arabinose, raffinose, crystal violet lactose, dextrine, salicin, mannitol, sorbitol, inositol. Slight acid but no gas in glycerine and inulin. Neither acid nor gas in dulcitol nor adonitol.

Plain Milk.—Acid—coagulation—gas. Acidity after five days, ·46 per cent., and after seven days, ·50 per cent.
Litmus Milk.—Acid—coagulation—gas.
Nitrates.—Reduced.
Indol.—Negative.
Diastatic Action.—Negative.
Remarks.—Optimum temperature, 25° C.
Thermal death point, 70° C.
Growth scanty at 37° C.
Type species, Culture K.
Culture G is regarded as a strain, although it did not ferment inositol, and fermented adonitol with acid and gas production.

REFERENCES.

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(3) Bergey, D. H.—Manual of Determinative Bacteriology, 1930.

TABLE 1.

	Methyl Red.	Voges Proskauer.	Uric Acid.	Citrate.	Nitrate Reduction.	Indol.	Diastase.	Motility.	Gelatine Liquefaction.	Dunham's Solution.
T.	−	+	++	++	+	−	−	+	−	+
A.	−	+	++	+	+	−	−	+	−	++
C.	−	+	++	++	+	−	−	+	−	++
R. *Aerobacter hibernicum*	−	+	++	+	+	−	−	+	−	++
G.	−	+	++	++	+	−	−	+	+	++
K. *Aerobacter liquefaciens*	−	+	++	++	+	−	−	+	+	++
W.	−	+	++	++	+	−	−	+	−	++

In the case of utilization of uric acid and citrate and growth in Dunham's solution + = slightly turbid.
++ = turbid.

TABLE 2.—CARBOHYDRATE FERMENTATIONS.

	Lactose.	Sucrose.	Maltose.	Dextrose.	Levulose.	Galactose.	Arabinose.	Raffinose.	Salicin.	Dextrine.	Inulin.	Glycerine.	Mannitol.	Sorbitol.	Dulcitol.	Inositol.	Adonite.	Crystal Violet.	Lactose Broth.
T.	++	+++	+++	+	+++	++	+++	+++	+++	+	–	+	+++	+++	–	–	+	++	+++
A.	+	+	+++	++	++	++	+++	+++	++	+	–	–	+++	+++	–	–	–	+++	+++
C.	++	+++	+++	+++	++	+++	++	+++	++	+	–	–	+++	+++	–	–	–	++	+++
R. *Aerobacter hibernicum* ...	+++	++	+++	+	+++	++	+++	+++	++	+	–	+	++	+++	–	+	–	+++	+++
G.	++	+	+++	++	+++	++	++	++	++	+	–	+++	+++	+++	–	–	+	+++	++
K. *Aerobacter liquefaciens* ...	++	+++	+++	++	+++	++	+++	+++	++	+	–	–	+++	+++	–	+	–	+++	+++
W.	+	+	++	++	+	++	++	++	++	+	–	+	++	+++	–	+	–	++	+

Percentage of gas formed in Durham tube :—

– = none + = 5 to 25 % ++ = 25 to 50 % +++ = over 50 %

TABLE 3.—CARBOHYDRATE FERMENTATIONS.

pH.

	Lactose.	Sucrose.	Maltose.	Dextrose.	Levulose.	Galactose.	Arabinose.	Raffinose.	Salicin.	Dextrine.	Inulin.	Glycerine.	Mannitol.	Sorbitol.	Dulcitol.	Inositol.	Adonite.
T. ... ... 5 days	6·0	5·9	5·4	5·6	5·4	5·4	5·6	5·8	5·4	7·0	7·6	5·9	5·4	5·8	7·2	6·2	
10 days	5·4	5·9	5·5	5·7	5·8	5·4	6·5	6·0	5·4	7·0	7·8	5·9	5·4	6·5	8·2	5·8	5·8
A. ... ... 5 days	5·6	5·9	5·4	5·7	5·4	5·4	5·8	5·9	5·5	7·0	7·6	6·5	5·4	5·6	7·9	7·6	
10 days	5·7	5·9	5·5	5·7	5·2	5·5	6·8	6·0	5·5	7·0	7·7	5·9	5·6	6·8	8·0	7·9	7·6
C. ... ... 5 days	5·8	5·9	5·5	5·7	5·4	5·4	5·8	5·9	5·5	7·0	7·4	6·5	5·6	6·2	7·8	7·5	
10 days	5·5	5·8	6·0	5·7	5·2	6·3	6·8	6·6	5·5	7·0	7·8	6·4	5·5	6·0	8·0	7·3	7·8
R. *Aerobacter hibernicum* 5 days	5·6	5·9	5·4	5·6	5·4	5·4	5·8	5·4	5·4	6·7	7·4	5·9	5·6	5·5	7·7	5·8	
10 days	5·6	5·9	5·5	5·6	5·8	5·4	6·2	5·4	5·4	6·2	7·8	5·9	5·6	5·8	7·8	5·8	7·6
G. ... ... 5 days	6·5	6·4	5·4	5·6	5·4	5·4	5·4	5·8	6·0	6·7	6·0	6·0	5·4	5·4	7·7	7·6	
10 days	5·9	6·4	5·5	5·8	5·8	5·4	6·0	6·0	6·0	6·0	5·8	5·4	5·5	5·4	8·0	7·8	6·8
K. *Aerobacter liquefaciens* 5 days	6·0	5·9	5·5	5·8	5·4	5·5	5·7	5·9	5·4	7·0	7·6	5·9	5·4	5·5	8·0	6·4	
10 days	5·7	5·8	5·4	5·6	5·2	5·4	6·8	6·0	5·5	7·0	7·9	5·9	5·4	6·8	8·0	6·2	7·8
W. ... ... 5 days	6·1	6·9	5·4	6·0	5·4	5·5	5·4	5·4	5·4	6·7	7·4	5·8	5·4	5 5	7·4	5·7	
10 days	5·9	6·8	5·5	5·9	5·2	5·5	5·4	5·4	5·5	6·6	7·8	5·4	5·4	5·5	7·9	5·8	7·8
Control	7·1	7·0	6·9	7·0	6·9	7·0	6·9	7·3	7·1	7·0	7·2	7·4	7·1	6·9	7·2	7·2	7·1

No. 10.

REPORT OF THE IRISH RADIUM COMMITTEE FOR THE YEAR 1930.

[Read April 28. Published separately September 15, 1931.]

Towards the close of 1929 the demand for radon had become so much greater than the available supply that patients were frequently kept for weeks waiting for treatment. The Committee accordingly suggested to the Council of the Royal Dublin Society that the members of the Society and the public generally should be asked to subscribe to a fund for the purchase of additional radium. This suggestion was approved by the Council, and, thanks to the generosity of those who supported the fund, a sum of nearly £10,000 was obtained. A full list of the subscribers has been published in the Society's Bi-Centenary Souvenir.

Sufficient funds having become available by May, 1930, the Committee purchased 496 mg. of radium, bringing the total quantity available up to 907 mg. As a result of this addition to the stock of radium, it is now possible to supply the needs of patients at short notice, thus adding appreciably to the chances of successful treatment. A further quantity of radium has been purchased since the close of the year.

Further improvements have been effected in the radon capillary apparatus, which have appreciably increased its efficiency. (See Sci. Proc. R.D.S., **20**, 1, 1930.)

21,533 mc. of radon were issued during the year 1930—an increase of close on 50 per cent. on the quantity for 1929.

Mr. T. J. Smith and Mr. M. A. Ellison were elected to the radium exhibitions falling vacant during the year.

The work of the Irish Radium Institute and the progress of radium therapy have suffered a grievous loss through the death of Dr. Walter C. Stevenson, who was one of the pioneers of this treatment. His name will ever be remembered in connection with the needle method of application, in whose development he played a prominent part.

Dr. Stevenson's death early in 1931 took place before his report on the very large number of cases which he had treated during 1930 could be written. This year's report accordingly suffers from the loss of a valuable feature, which has never previously been absent since the foundation of the Institute in 1914.

Reports from some other large users of radon are printed below.

Report by Oliver Chance, M.B., B.Ch.,

Sir Patrick Dun's, Richmond, and Coombe Hospitals.

List of Cases Treated.

Malignant, 110.

Carcinoma Buccal Cavity and Air Passages	36	Carcinoma Thyroid	1
Carcinoma Uterus	11	„ Bladder	1
„ Breast	9	„ Penis	1
„ Skin	13	Branchial Carcinoma ...	2
Rodent Ulcer	14	Carcinoma Glands	4
Carcinoma Rectum	3	Sarcomata	6
„ Anus	3	Brain Tumours	5
		Mixed celled Parotid Tumour	1

Non-Malignant, 12.

Menopausal Hæmorrhage ...	2	Hodgkin's Disease	1
Exophthalmic Goitre ...	3	Keloid	1
Naevi	3	Tubercular Peritonitis ...	2

Carcinoma Buccal Cavity and Air Passages, 56.

The primary growths were treated by implantation, except in a few cases (carcinoma of gums and hard palate), in which radium bearing plates were used. The element or radon was screened by 0·6 mm. of platinum, and the needles had a linear intensity of 0·66 mg., or 1·8 mc. per cm. Birkett's technique of implantation and dosage was employed.

Two cases in which a small growth had occurred on a tongue which was the site of marked chronic glossitis were referred to surgeons for excision, because it was felt that the condition of the tongue rendered irradiation inadvisable. Both of these cases are still free from disease.

All patients were asked to report 8 weeks after their primary growth had been treated. If mobile glands were present, a gland dissection was done. If the glands were fixed, they were treated either by implantation or by surface application.

In three cases in which the primary growth appeared clinically to be a particularly radio-sensitive one, and in which the cervical glands were involved, the neck was first treated by deep X-ray therapy (Finzi's six-field method) or

by semi-distance treatment. Six weeks later the primary was treated. In all three cases both primary growth and secondary glands had considerably decreased in size, but in none of them did the evidence of gland involvement entirely disappear.

Summary of Cases.

Cases seen.	*Cases treated.*	*Free from disease in February,* 1931.		*Untraced.*
		Primary growth alone considered.	Primary glands considered.	
56	36	15 = 41·7 %	6 = 16·6 %	5

It was found impossible to persuade more than a small percentage of cases to attend 8 weeks after the primary had been treated. Many were never seen again. Others arrived 4 or 5 months later with fixed masses of glands where originally no glands were palpable. It is therefore evident that, if possible, the glandular areas must be treated at the same hospitalization as the primary.

It is difficult to see how this can be done, as there is not enough accommodation to keep each patient in hospital until the primary growth is healed without lessening the total number of cases treated.

Carcinoma Cervix Uteri.—15 cases.

In the treatment of these cases it is generally recognised that the best results follow the Stockholm technique. Nevertheless, after careful consideration, one was forced to discard it, for, owing to the difficulties already alluded to, it is necessary to carry out the whole treatment during a single stay in hospital. The accommodation is not sufficient to keep each patient in hospital for at least 5 weeks without greatly lessening the number of cases which could be treated. Implantation has been substituted for surface applications, owing to its greater simplicity.

The following technique is used:—Pre-operative douches are given for two or three days. Under general anæsthesia, 12 mgr. of Ra element or 24 millicuries screened by platinum 6/10 and German silver are inserted into the uterine cavity. 8–18 needles, containing 1, 1·33, and 2 mgrs., or an equivalent amount of radon, and having a linear intensity of ·66 mgr. per cm., are implanted into and around the growth. The vagina is then packed, and the needles and central tubes are left in position for 8 days. In two cases the needles have been removed on the sixth day, and later inserted for a further 4 days. Maximum dose given, 7,680 mgr.-hrs. Average dose, 5,560 mgr.-hrs.

No ill-effects have followed this method of treatment. In only one case did a temperature of over 100° occur. This patient had been running a temperature before treatment was given.

Table of Cases.—15.

Operable, 3.	*Duration of symptoms.*	*Section.*	*February,* 1931.
Mrs. B. (50 yrs.)	4 months.	+	Well.
Mrs. F. (64 yrs.)	2 „	+	„
Mrs. M. (54 yrs.)	7 weeks.	Not taken.	„
Border-line, 5.			
Mrs. E. (45 yrs.)	6 months.	„ „	„
Mrs. G. (38 yrs.)	4 „	„ „	„
Mrs. M'D. (50 yrs.)	6 „	„ „	„
Mrs. M'R. (29 yrs.)	6 „	„ „	No symptoms for 11 mths.; now pelvic recurrence.
Mrs. W. (38 yrs.)	2 „	„ „	Recurrence 3 months after treatment on vault. Given deep X-ray. Whole pelvis involved 2 months later. Death 12 months later.
Inoperable, 3.			*In December,* 1930.
Mrs. K. (52 yrs.)	12 „	„ „	No symptoms. (Not examined since treatment.)
Mrs. R. (32 yrs.)	6 „	„ „	No symptoms. Pelvis extensively involved.
Mrs. W. (64 yrs.)	5 „	„ „	Well.
	Mortality nil.		
Hopeless, 4. (Not treated.)			
Mrs. M'D. (73 yrs.)	7 „	+	Died in 2 months.
Mrs. M. (30 yrs.)	9 „	Not taken.	Gross involvement of bladder.
Mrs. S. (47 yrs.)	6 „	„ „	——
Mrs. R. (54 yrs.)	19 „	„ „	Died 4 days after examination. Anæmia profound.

The operability rate was decided by the referring gynæcologist, who also made the biopsy in those cases in which this was done.

These figures are of little value owing to the short time which has elapsed since treatment was given. But at least they suggest that one is justified in using this 8-day method until the Stockholm technique becomes practicable.

Carcinoma Breast, 13.

No operable cases were treated. Post-operative prophylactic treatment was given by deep X-ray therapy. The cases to which this was given are not

discussed. In three cases treatment was undertaken, not with any hope of effecting a cure, but in order to prevent extensions of ulceration of the skin. In all 3 cases this was successful.

Technique.—Keynes' technique of implantation was used, except that an incision was made over the axilla, and needles were implanted here under direct vision.

Cases seen.	*Treated.*	*Apparently well.*	*Improved.*	*Dead.*	*Untraced.*
13	9	1	5	2	1

Carcinoma of Skin.

These cases were treated either by implantation or by surface application. In no case was gland involvement present.

Cases seen.	*Treated.*	*Apparently well.*	*Untraced.* (Probably well.)
14	13	10	1

In the remaining 2 cases the growth was shown microscopically to be sebaceous carcinoma. One of these, a very large growth on the forehead, reacted well; some bony necrosis occurred, and this has not yet healed. The other was little affected by radium, and was later treated surgically.

Rodent Ulcers.

All the cases seen were suitable for treatment, which was given either by surface application (1–1·5 cms.) or by implantation.

Cases seen.	*Treated.*	*Apparently well.*	*Unaffected.*
14	14	13	1

Three cases had had previous X-ray or radium treatment. One of these was entirely radio-resistant.

Carcinoma Rectum, 9.

The results here were unsatisfactory. Nine cases were seen, of which three were treated: two by coccyx and implantation. The third refused excision of colostomy, and was treated by deep X-ray therapy. A three-field method was used.

Results.—No evidence of improvement in any case.

Carcinoma Anus, 4.

Three cases treated. One case is well. One requires further treatment after removal of coccyx. The primary growth in the third is smaller, but fixed, enlarged glands are present in both groins.

Carcinoma Thyroid, 1.

Treatment by implantation and surface application. Untraced.

Carcinoma Bladder, 1.

Very advanced; treated by diathermy and implantation. Died 3 months later from extensive pelvic involvement.

Carcinoma Penis, 1.

Primary not yet healed. Enlarged glands present in both groins. These are movable, and suitable for operation.

Branchial Carcinoma, 2.

Two cases were treated by interstitial irradiation through an open incision. In neither case did the mass disappear entirely. One has since died.

Carcinoma of Lymph Glands, 4.

In four cases, in which the primary growth had been successfully removed surgically, inoperable malignant glands in the neck were treated. One of these patients had been free from disease for 4 years.

Two cases were treated by implantation, one by a combination of this and "semi-distant" treatment, and one by the latter method alone.

In no case did definite disappearance of disease occur, and in the last there was a very definite increase in the rapidity of growth.

Sarcoma, 6.

(2 neck, 1 antrum, 1 scalp, 1 foot, and 1 buttock.)

In only two cases was radium alone used. In the remainder interstitial irradiation was combined with deep X-ray therapy.

Marked temporary improvement occurred in five cases, three of whom have since died. The sixth, a round-celled sarcoma arising from the muscles of the buttock, shows no evidence of recurrence 5 months after treatment.

Brain Tumours, 5.

Five cases under the care of Mr. McConnell were given radium treatment at the Richmond Hospital.

Three received "semi-distant" therapy. In the remaining two, needles were implanted into and round the growth.

Treatment has been given too recently for any conclusions to be drawn from these cases.

Mixed-celled Parotid Tumour, 1.

This case was treated by excision. Needles were implanted into and around the resulting cavity. Eight months after treatment there is no sign of recurrence.

NON-MALIGNANT.

Uterine Hæmorrhage, 2.

Of the two cases treated, one was excessively anæmic, the other was very obese; and for these reasons operation was contra-indicated.

1,600 mgr.-hrs. were given by means of an intra-uterine application. Symptoms have ceased in both cases.

Exophthalmic Goitre, 3.

A modification of Ginsburg's method has been recently adopted in treating this disease. 100 millicuries, divided among five brass tubes, are applied to the neck at a distance of 3 cms. A dose of 50 mcd. is given. This produces a faint erythema. Eight weeks later the patient is examined clinically, and the basal metabolism estimated. If necessary, the treatment is repeated. This is done at eight weekly intervals until a clinical cure has been obtained.

Three cases are at present under treatment (two moderate and one severe case). At the first re-examination all three cases were found to have improved very considerably, both subjectively and objectively. They have each been given a second exposure, but a second re-examination has not yet been made.

While the evidence is still very slight, one has gained a strong impression that radium is a more satisfactory method of treatment than is X-ray therapy.

Nævi, 3.

Two cases of cavernous nævi treated by β-irradiation, given in fractional doses, have been replaced by a faint white scar. An attempt was made to cure a third similar case by means of pure gamma irradiation. At the end of three exposures there is no apparent change in the condition.

Hodgkin's Disease, 1.

This patient was in a very advanced state of disease. His neck was treated by means of a radium-bearing collar in an effort to relieve dyspnœa. He died while treatment was in progress.

Keloid, 1.

This was a very large keloid on the face, following a burn. It has reacted wonderfully well to irradiation at 1·5 cms. distance.

Tubercular Peritonitis, 2.

Two cases treated by Stevenson's method both show improvement.

Conclusions.

Certain general conclusions can be drawn from the year's work.

1. When suffering from cancer, the people of Ireland usually delay seeking medical advice until too late. This could be rectified to a certain extent by "Cancer Propaganda," such as is commonly used in continental countries.

2. At present there is an excellent arrangement in force by which county authorities send cancer patients to hospital, and pay a fixed sum for their treatment there. More, however, is needed to put the treatment of malignant disease on a proper footing. In an agricultural country such as Ireland most of the patients live long distances from the treatment centre. Some official arrangement must be made by which these will attend there for inspection at regular and frequent intervals. This could be done in the way which has been adopted in Sweden.

3. Radium and deep X-ray therapeutists must work in closer union. In the past these two forms of treatment were regarded as alternatives. Actually they are complementary, and the best results can only be obtained when they work in double harness.

These final remarks are assertions of the obvious. However, until it is recognised, the truth cannot be reiterated too often.

In conclusion, I wish to thank Dr. Poole and his staff at the Royal Dublin Society most sincerely for the very courteous and efficient way in which they have carried out their difficult task.

Report for the Irish Radium Committee (Royal Dublin Society) of Radium work carried out from March, 1930, to March, 1931.

By Andrew Charles, F.R.C.S.,

Medical Superintendent, City of Dublin Skin and Cancer Hospital.

Cases Treated with Radium. Total, 83, as follows:—

Cancer of Tongue involving roof and floor of Mouth	23	Rodent Ulcers	5
Cancer of Face	14	Malignant Disease involving the Antrum	3
Cancer of lower part of Face involving Neck	6	Epithelioma of Hand	2
Cancer of Ear	4	Malignant Disease of Genito-Urinary Tract	1
Cancer of Lip	10	Carcinoma of Eye	4
Cancer of Breast	5	Carcinoma of Rectum	2
Cancer of Leg	3	Generalised Lymphadenoma	1

Of the above cases, 17 were females, 66 were males. The average age of the patients was 55 years.

Of the 23 cases of cancer of tongue involving roof and floor of mouth, 4 of these cases involved the tongue only, and did remarkably well. One of these tongue cases was treated about April, 1930, returns to hospital periodically for inspection, and is apparently a complete cure. The other 3 tongue cases are also under observation, and so far show no signs of recurrence.

Of the remaining cases of cancer of tongue involving roof and floor of mouth, 7 were old patients, ages averaging about 70, and the disease rather advanced. Two had previously received radium.

These cases made no progress whatsoever, as their general condition was in a low state when admitted.

Two cases, both males, aged about 45 years, showed temporary improvement, but eventually got worse.

Four cases are still in hospital, in two of which improvement is rather doubtful.

Of the rest, two died, and the remainder are under observation, and show no signs of recurrence.

14 cases of cancer of face, 10 of which were males, 4 females; average ages, 50–70.

Four of these cases are still in hospital, and responding rapidly to treatment; two were old patients, and the disease rather advanced. The results of treatment were wonderful, and both patients were discharged much improved some months ago. They have not reported.

One case, an old man about 70, died. The remaining seven are under observation and giving satisfaction.

Cancer of lower part of face involving the neck—6 cases, 4 of which were males, 2 females. Ages ranging 35–60.

One is still in hospital, and not going on satisfactorily.

One case, a young man of 38 years, had previously received radium. He showed temporary improvement, but subsequently succumbed.

Four cases were discharged much improved, but three have not reported.

10 cases of cancer of lip—9 males and 1 female.

One case was a man, whose age was 70, who had a history of four months' duration. The malignant disease of the lip was a complete cure, but unfortunately he died of valvular disease of the heart when about to be discharged.

Two cases were discharged some months ago much improved, and the condition obviously checked. They have not reported.

Of the remaining seven cases, one is a case of about two years' duration. He had radium treatment, and in the beginning did well. He was discharged and kept under observation. Recently he was admitted to hospital for further treatment, to which he did not respond.

One was doing well, but left before treatment was completed.

Of the remaining five, one gave a history of having had radium treatment previously. He made progress and was discharged. Of the rest, the malignant condition greatly improved. They are still under observation, and, on last examination, showed marked improvement.

5 cases were cancer of breast—all women; average age, 55.

One case was very advanced; it was a scirrhus cancer of both breasts, the general condition being very unfavourable. The patient at first showed signs of slight improvement, but rapidly declined, and is reported dead.

In two cases there was complete disappearance of the tumour. Two cases are still under treatment and progressing favourably.

4 cases of cancer of ear—3 males, 1 female. Ages average about 60.

One case, a man 60 years of age, with a history of two years' duration, improved temporarily, but he subsequently died.

One case responded actively to treatment, and was discharged much improved.

Two cases were unsatisfactory, as the disease was advanced, and patients did not complete treatment.

5 cases of rodent ulcers—all men; average age, 50 years. Site, outer angle of eye.

Four gave a history of a few months' duration, two of whom were discharged cured, and two are still in hospital, showing signs of cure.

In the fifth case the patient has been periodically in hospital for fifteen years, and is still under observation. Although the whole face is involved, the disease has been checked for some years.

2 cases of epithelioma of hand, both males.

They did remarkably well, and were discharged apparently cured. Both report periodically, and are going on satisfactorily.

3 cases of cancer of leg—2 females, 1 male.

The two females did well and were discharged. The third case was discharged without any signs of improvement, and is reported dead.

Of the three cases involving malignant disease of the antrum, two have done exceptionally well, and report periodically. One did not complete treatment, and has not reported.

4 cases of carcinoma of eye—2 males, 2 females.

The two female cases did remarkably well, and were recently discharged from hospital, showing signs of marked improvement.

The two males were unsatisfactory; both very old, and general condition unfavourable. They were discharged, and have not since reported.

2 cases of carcinoma of rectum—both females.

One case did not improve, as the condition was too advanced. She was discharged, and subsequently died.

The second case did well and was discharged, and has not reported.

1 case of carcinoma of the genito-urinary tract—female, aged 40.

She received deep X-ray previous to radium treatment. This case improved rapidly, and was discharged.

1 case generalised lymphadenoma—a young man, aged 22 years.

This case was hopeless.

The total known mortality amongst the 83 cases was 10·8 per cent.

Report by John A. Geraghty, M.B.,

Mater Misericordiae Hospital.

1. O'R., female, age 50.—Cancer of uterine cervix infiltrating wall of vagina. 4/4/'30–6/4/'30. — Radium treatment. 8/4/'30–11/4/'30. — X-ray treatment. 12/4/'30–15/4/'30. — Radium treatment. 25/6/'30–28/6/'30. — Radium treatment. 3/7/'30–8/7/'30. — X-ray treatment. 26/8/'30. — Primary focus healed.

2. M'D., female, age 45.—Inoperable cancer of uterine cervix. Red cell count, 3,500,000. 16/7/'30–18/7/'30.—Radium treatment. 11/8/'30.—Much improved; discharge less; no hæmorrhage. 12/8/'30–15/8/'30. — Radium treatment. 20/8/'30–27/8/'30.—X-ray treatment. 10/10/'30.—Condition worse; hæmorrhage recurred. 14/10/'30–16/10/'30. — Radium treatment. Died 7th November, 1930.
3. W. A., male, age 62. — Inoperable buccal carcinoma (R. lower alveolus). Tumour first noticed four months ago, and is now approximately 6 cm. × 4 cm. 16/7/'30–24/7/'30. — Radium treatment. 11/8/'30. — Much improved; tumour markedly reduced in size; overlying skin epilated; no erythema. 24/10/'30.—Condition still satisfactory; hair has regrown on cheek. 24/10/'30–7/11/'30.—Radium treatment. To report for further examination.
4. M. N., female, aged 6 months. — Cavernous nævus left cheek. 28/11/'30–30/11/'30.—Radium treatment. 6/2/'31.—Nævus paler and less elevated. 6/2/'31–8/2/'31.—Radium treatment. To report for further examination.

Report by P. MacCarvill, M.B., B.Ch.

Total number of cases treated from 1st January, 1930, to 31st December, 1930, = 58.

Cases were divided as follows:—

A.—Malignant Cases.

Tongue	14
Cervix Uteri	8
Basal-celled Epithelioma of Skin	5
Epithelioma of Lip	5
Epithelioma of Cheek ...	5
Epithelioma of Hard Palate ...	2
Mammary Cancer	2
Epithelioma of Tonsil ...	2
Epithelioma of Maxillary Antrum	1
Adeno-Carcinoma of Rectum ...	2
Sarcoma of Maxilla	1
Epithelioma of Cervical Glands	2
Endothelioma of Forearm ...	1
Epithelioma of Urethra ...	1
Carcinoma Body of Uterus ...	2
Vault of Vagina	1
Axillary Glands	1
Total	55

B.—Non-Malignant Cases.

Metrorrhagia	1
Haemangioma	1
Tubercular Ulceration of Nose	1
Total	3

Group 1.

MALIGNANT DISEASE OF TONGUE.

(14 Cases.)

A.—Clinical Features.

Site		Mandible involved.	Tonsil involved.	Metastases in Cervical and Submaxillary Glands.	No Metastases.	Sex.
Posterior Third.	Anterior Two-thirds.					
6	8	3	3	12	2	14 males

B.—Treatment and Technique Employed.

Radium

Needles.	*Surface Application.*	*Dosage and Time factor.*	*Combined Deep X-Rays and Radium.*	*Combined Radium and Surgical Diathermy.*
Platinum, 0·5 mms. effective screenage, containing Radon varying in strength from 1·9 to 3·2 millicuries. Implanted and stitched in tongue substance.	Tubes, with effective screen of 3 mms. brass. Distance from skin 3·6 cms. Containers were in strength varying from 5 to 20 millicuries.	(1) Dose from needles in tongue varied from 7·5 M. C. D. to 17 M. C. D. (2) Dose from ext. Surface application varied from 6,000 to 12,000 millicurie hours (45 to 90 M. C. D.). Required dosage in all cases except two reached in not less than five days.	8 cases treated by radium internally and deep X-rays externally. Factors used with X-rays— 180 K. V., 4 milliamps. Filter—½ mm. copper, 1 mm. aluminium. Distance, 30 cms. Field, 12 × 9 cms. 15 × 10 cms. One or both sides of neck treated.	3 cases treated. 1 case had fungating ulcer removed prior to Radium treatment. 2 cases had surface of mandible coagulated.

C.—Results.

Clinically well.	Much improved.	Relief from pain without other improvement.	Died.	No Report.	Total.
4	4	1	3	2	14

Group 2.

CERVIX UTERI and BODY OF UTERUS.

(8 Cases.) (2 Cases.)

A.—Clinical Features.

Inoperable.	Spread to Vaginal Walls.	Adherent to Rectum or Bladder.	Spread to Pelvic Structures.	Age.
8	4	7	6	Youngest, 34. Oldest, 71.

B.—Treatment and Technique Employed.

Radium

Cavitation by means of Uterine Container.	*Surface Application on Vaginal Surface of Cervix.*	*Dosage and Time Factor.*	*Combined Radium and Deep X-Rays.*
Container, with effective screen of 3 mms. brass, reaching from fundus of uterus to ext. os. Strength of Radon varying from 25 to 40 millicuries.	Circular brass container, with 3 mms. screen. Varies in size according to vaginal capacity. Radon content varies from 40 to 60 millicuries.	Total dose reached in not less than 4 days. (1) Dose from uterine container varied from 1,800 millicurie hours to 3,000 millicurie hours. (2) Dose from circular container varies from 3,000 millicurie hours to 5,500 millicurie hours.	5 cases with pelvic metastases treated by deep X-rays following local treatment by Radium. Two anterior and two posterior fields were used. Working conditions of X-ray similar to those employed in Group 1.

C.—Results.

Clinically well.	Much improved.	No improvement.	Died.	No report.	Total.
2	3	2	3	2	12

N.B.—In all the cervical cases a short brass speculum of the necessary size is left in vagina during treatment. This protects bladder and rectum from injury.

Group 3.

SUPERFICIAL MALIGNANCY.

(15 cases.)

A

5 cases.
Rodent ulcer type.
(Basal-celled epitheliomata.)

3 cases of superficial type, not eroding bone or cartilage.

All three treated by radium plate, using 2 mm. brass filter and a dose varying from 800 millicurie hours to 1,200 millicurie hours.

2 cases eroding bone.

Both cases treated by surgical diathermy, followed by radium.

[Case 1, in which eye and maxillary antrum were involved, died during treatment.]

Case 2.—Radium plate of 3 mms. brass, 6 × 6 cms., and 3 cms. distance, with a radon content of 40 m.c.s.
Dose, 4,000 millicurie hours.
(30 m.c.d.)

B.

5 cases.

Epitheliomata of lip and cheek, without metastases.

All treated by wax mould impregnated with needles with effective screenage of 0·5 mms. platinum.
Distance, 1·5 cms.
Total dose varied from 1,500 millicurie hours to 2,400 millicurie hours.

C.

5 cases.

Epitheliomata lip and cheek, with metastases.

Radium used on primary lesion.
Deep X-rays on glandular metastases.

Radium used as in cases "*B*".

Deep X-rays as in groups 1 and 2.

Results.

A.

Rodent ulcer group.

3 apparently cured.

1 much improved.

1 died.

Total, 5

B.

4 apparently well.

1 Recurrence of primary lesion and secondary spread.

Total, 5

C.

Primary lesion cleared up in all five.

Subsidence of glandular enlargements in 3.

No marked improvement of glandular enlargement in 2.

Total, 5

Group 4.

(19 cases remaining from General List.)

Hard Palate.

(2 cases.)

Case 1. Died.

Case 2. Has metastases in neck.

Mammary Cancer.

(2 cases.)

Case 1. Female. Living, but apparently getting deposits in axilla.

Case 2. Male. Living, and quite free from clinical symptoms.

Epithelioma of Tonsil.

(2 cases.)

Case 1. Died.

Case 2. No report, but presumed dead.

Epithelioma of Maxillary Antrum.

(1 case.)

No report.

Adeno-carcinoma of Rectum.

(2 cases.)

Case 1. Female. Living, and apparently well.

Case 2. Male. Died.

Sarcoma of Maxilla.

(1 case.)

Youth, aged 20 years. Living, and free from clinical symptoms after 7 months.

Epithelioma of Cervical Glands.

(2 cases.)

Both living, but both complaining of pains.

Endothelioma of Forearm.

(1 case.)

Primary lesion clinically well.
No trace of recurrence after 8 months.

Epithelioma of Urethra.

(1 case.)

Female. Died.
Rapid extension to groins.
Failed to respond to deep X-ray treatment.

Vault of Vagina.

(1 case.)

Occurred in this site 3 months after operation for complete hysterectomy.

Died.

Axillary Glands.

(1 case.)

Irremovable at time of operation for mammary cancer.

Living, and apparently well.

Non-Malignant Cases.

(3 cases.)

Metrorrhagia.

Symptoms disappeared following dose from uterine container of 1,200 millicurie hours.

Patient well.

Hæmangiona.

Three doses of 400 millicurie hours at monthly intervals.

Lesion completely disappeared, leaving slight pigmentation in original site.

Tubercular Ulceration of Nose.

Lesion completely healed.

Patient well.

Report by Oswald J. Murphy, M.B., B.Ch., B.A.O.,

St. Vincent's Hospital.

Radium therapy is claiming better and better results each year in the treatment of cervical cancer, which is very gratifying. This is undoubtedly the result of improved technique.

I have been using a hard paraffin wax—moulded to suit each case—as a means of holding the tubes in position. A patent central tube allows free drainage. The advantages gained are that the wax can be moulded so as to keep bladder and rectum at a safe distance from radiation sources, and that accuracy of both distance and disposition of the tubes of radium is more easily maintained. A wax with a melting-point of less than 160° is too soft.

There seems to be a persistent objection on the Continent to needling malignant growths in this region, the plea being that needling accelerates the rate of malignant growth. Why, if it is not only permissible, but highly advisable, to needle such conditions as cancer of the tongue, skin, and breast, is needling of the cervix objected to? I know of no published figures which show any resulting harm. I think that the further development of this technique will produce end results superior to any existing at present. I have lately employed this method, and I like it for its obvious advantages. Firstly, the needles are embedded exactly where they are most needed—in and around the malignant tissues; secondly, there is a more uniform irradiation; thirdly, the amount of radiant energy used is not concentrated into one or two tubes in the fornices, with the accompanying risks of bladder or rectal complications. One can, of course, look at this question of needling from another standpoint. The percentage of cures following radium treatment in cancer of the uterine cervix is higher than those prevailing for buccal and breast cancer. Is it because it has been the practice to needle these conditions? The question of access obviously does not enter into it, as all three areas are equally accessible. Cancer in the mouth and breast ought to attract the attention of the sufferers at an earlier date than in cervix cases. Is it because needle implantation is carried out that this state of affairs exists?

Cases Treated by Radium Emanation supplied by the Royal Dublin Society Radium Institute.

	No. Treated.	Cured.	Improved.	Lost sight of.	Died.
Rodent Ulcers	35	33	—	2	—
Epithelioma of Ear	3	1	1	1	—
„ „ Lip	5	3	—	1	1
„ „ Face	14	8	3	2	1
„ „ Tongue Floor ...	3	2	—	—	1

	No. Treated	Cured.	Improved.	Lost sight of.	Died.
Epithelioma of Middle Third ...	4	1	1	—	2
„ „ Posterior Third ...	5	1	2	—	2
„ „ Posterior Third (involving Tonsil)	2	—	—	—	2
„ „ Palate	2	2	—	—	—
Cancer of Oesophagus	2	—	—	—	2
„ „ Pharynx	1	—	1	—	—
„ „ Larynx	2	—	1	—	1
„ „ Thyroid	1	—	—	—	1
„ „ Branchial Cleft ...	3	—	1	—	2
„ „ Breast	5	—	3	—	2
„ „ Breast (Secondaries) ...	6	—	3	—	3
„ „ Rectum	2	—	1	—	1
„ „ Anus	1	1	—	—	—
„ „ Uterine Cervix ...	4	2	1	—	1
Epithelioma of Hand	6	5	—	—	1
„ „ Leg	1	—	—	—	1
„ „ Abdomen ...	1	—	—	—	1
Melanotic Sarcoma	1	—	—	—	1
Lupus Vulgaris	2	2	—	—	—
Granuloma Annulare	1	1	—	—	—
Warts	5	5	—	—	—
Pruritis Ani	1	1	—	—	—
„ Vulva	1	1	—	—	—
Lichen Planus	1	—	1	—	—
Exophthalmic Goitre	1	—	1	—	—
Keloids and Scars	6	4	2	—	—
T.B. Cervical Glands	2	1	1	—	—
Hodgkin's Disease	2	—	1	—	1
Nævi	5	4	1	—	—
Uterine Hæmorrhages	3	2	1	—	—
Deafness (Oto-Sclerosis) ...	2	—	—	—	—
	141	80	26	6	27
Figures for the Malignant Cases only	109	59	18	6	27
Excluding Rodents	74	26	18	2	27

The cases put down as cures are those which over varying periods of the last year in which they were treated present no signs of any malignant activity.

The only alterations in technique since last report were increased screenage—2 millimetres of lead—for surface applications, and a decrease in the emanation strength in needles for implantation—1·5 to 2·5 millicuries per needle.

Report by C. Conor O'Malley,

Surgeon, Eye and Ear Department, Central Hospital, Galway.

Notes on Cases of Malignant Growths treated with Radon.

1. Mr. J. C., age 54.—First seen on 3/8/'29. Growth involving left mid-turbinate. Operation—Mid-turbinate removed; pathologist's report, actively malignant. Discharged hospital. Re-admitted 2/10/'29. Growth extensively involving left side-wall of nose, with copious purulent discharge and hæmorrhage. Radon, 396 mc.-hrs. in 1 mm. silver needles. Hæmorrhage ceased; much improved generally; discharged. Re-admitted 8/1/'30. Patient very anæmic and weak. Growth invaded right side of nose. Copious hæmorrhage from right side; both cavities of nose completely blocked. Impossible to control hæmorrhage by any means. Radon, 396 mc.-hrs. in 1 mm. silver, on 12/4/'30. On 25/4/'30 discharged hospital; condition much improved; hæmorrhage completely ceased. Re-admitted 19/6/'30. Fungating growth filling naso-pharynx, and projecting down pharynx, pushing soft palate down and forward. Patient very weak. Swallowing almost impossible. When patient dozed off to sleep, he got choking attacks, and woke up with acute dyspnœa. Radon, 547 mc.-hrs. in 1 mm. silver needles buried in growth with permanent tracheotomy tube. Complete disappearance of obstructing mass; swallowing completely recovered; breathing became quite normal, and tracheotomy tube removed. Patient re-admitted and discharged on several subsequent occasions. Growth now extending towards inner canthus of left eye, apparently spreading to skin surface along the lacrymal groove.

Remarks on case.—On two occasions death was imminent in a few days: in April, 1930, from hæmorrhage, and in June, 1930, from dysphagia and dyspnœa. Radium was the only hope of saving life on those occasions.

2. Mr. J. C., age 50.—First seen 20/5/'30. Very soft, rapidly-growing tumour of right superior maxilla, involving the anterior surface of the bone and the right posterior half of the alveolar process, probably sarcoma. Radon, 878·4 mc.-hrs. in 1 mm. silver needles. Apparently complete disappearance of growth. The part of alveolar process involved replaced by a large hole. No slough of bone. On 12/8/'30 re-admitted. No recurrence below, but rapid extension above, hard nodular masses surrounding margin of orbit; imminence of fungation on to skin. Radon, 1,368 mc.-hrs. Very intense reaction, with sloughing of soft tissues and portion of malar bone. Severe conjunctivitis and chemosis. At present there is no recurrence at areas treated. There is, however, an extension appearing at posterior part of hard palate.

Remarks on case.—The second dose was apparently too big. Notwithstanding the intense radiation in close proximity to eye, there were no lens opacities or fundus changes; vision not impaired. Screening, 1 mm. silver.

3. Mrs. M. H., age 65.—First seen 5/5/'30. Tumour starting in right ethmoid or antrum, occluding right nasal cavity, involving right side of hard palate, bulging out right side of face, and partially closing right eye. Radon, 1,132·8 mc.-hrs. in 1 mm. silver needles. Severe reaction; no slough; rapid shrinking of tumour at all points. Re-admitted 20/11/'30. Recurrence of growth at hard palate. Radon, 844 mc.-hrs. in 1 mm. silver needles. Moderate reaction; disappearance of recurrence; no slough.

Remarks on case.—In this type of case, assuming it were seen at the earliest moment a diagnosis was possible, an attempt at removal would be unpromising; but radiation would likely have given a good lasting result.

Patient not seen since last treatment.

4. Mr. P. K., age 65.—First seen 29/9/'30. Epithelioma covering greater part of soft palate, and extending on to upper part of pillars of left tonsil; part of growth covering area of hard palate. Radon, 1,170 mc.-hrs. in 1 mm. silver needles. Slight immediate reaction. Later a good deal of sloughing in neighbourhood of uvula. Growth completely disappeared. Patient left hospital before slough separated; not seen since.

Remarks on case.—Immediate result good, though dose apparently too big. Case inoperable.

5. Mr. J. W., age 60.—First seen, 13/12/'30. Sloughing ulcer epithelioma about the size of a two-shilling piece on left side of hard palate, and extending over anterior pillar of left tonsil. History vague. No palpable extension in cervical lymphatics. Radon, 554·3 mc.-hrs. in 1 mm. silver needles in "growth," and 156·8 mc.-hrs. in 2 mm. lead applicator to adjacent cervical area on 17/12/'30. Examined three weeks later. Ulcer completely healed, with smooth healthy scar. To have a further small dose at a doubtful point at lower margin of scar.

Remarks.—Apparently a very good immediate result.

Notes on progress. One month after first application of Radon an extension of growth appeared at the junction of anterior pillar of tonsil and tongue.

An application of Radon 108 mc.-hrs. in 1 mm. silver needle applied. Patient examined on the 7/7/'31, nearly seven months after first treatment with Radon. A smooth healthy looking scar at site of growth, no trace of recurrence, no glandular involvement. Patient is quite comfortable, and has put on weight. Result to date very good.

No. 11.

ON A METHOD OF DISTINGUISHING THE SEEDLINGS OF SWEDISH TURNIP[1] (*BRASSICA NAPUS* L. VAR. *NAPOBRASSICA* (L.) REICHB.) FROM THOSE OF RAPE (*BRASSICA NAPUS* L. VAR. *BIENNIS* (SCHÜBL. ET MART.) REICHB.).

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AND

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(Plate 3.)

[Read June 16. Published separately September 21, 1931.]

The seeds of the several kinds of Brassicae cultivated in Ireland resemble one another so closely in outward appearance that up to the present no reliable criteria for distinguishing between them have been discovered. The plants of this important genus are employed for many diverse yet specific purposes—domestic, agricultural, and industrial—and it is not surprising, therefore, that the failure of the botanist to devise means of identifying their seeds has been the cause of recurring trouble between grower and seed merchant. The earliest systematic observations made it clear that no reliable naked-eye differences exist between the seeds of, say, cabbage and turnip or between those of turnip and swede.

Failure to establish any satisfactory scheme of classification upon the basis of external characters led naturally to the microscopic examination of the seed coats, and here a certain degree of success was at once attained. Schröder (10) in 1871 appears to have been the first to describe slight differences in the

[1] More strictly yellow-fleshed swede, the kind universally cultivated in Ireland. The nomenclature is that of the monograph of O. E. Schulz (9). In the case of the swede the risk of confusion is slight, although its synonymy is extensive. With rape, however, the matter is not so simple, owing to the fact that there are several different kinds of rapelike plants which appear to be more or less distinct genetically. The plant dealt with here is widely but not extensively grown in Ireland as forage for sheep and cattle. It is the "broad-leaved rape," "winter rape," "winter swede rape" ("Winterraps" of German authors).

histology of the seed coats which enabled him to arrange the forms which he studied in three groups, viz.:—

I. Mustard (*Brassica nigra,* L.).

II. Cabbage Tribe (*Brassica oleracea,* L.).

III. Turnip (including swedes and rapes) (*Brassica napus,* L., and *B. cantestris,* L.).

Further investigations of the seeds and seed coats were carried out by Sempelowski (11), von Hohnel (3), and Harz (2). These workers confirmed and supplemented somewhat the observations of Schröder; Harz, for example, showed that there are slight but constant microscopic differences between the seed coats of the turnips and turnip rapes (derivatives of *B. campestris,* L.) on the one hand and those of the swedes and swede rapes (derivatives of *B. napus* L.) on the other.

The next important study of these seeds seems to have been made by Kondo (4) in Japan. He investigated the seeds of thirty-five different sorts of Brassica grown in that country. He tabulated his results under many headings, viz.: shape of seed, colour, size, weight of one thousand seeds, and microscopic characters of the seed coats. He also germinated the seeds, and in every case described the cotyledons, the first foliage leaves and the colour of the hypocotyl. He appears to have been the first in the case of the Brassicae to study the characters of the seedlings in conjunction with those of the seeds. Combining the characters of the seeds and the seedlings, he constructed an artificial key to be used for the identification of thirty of the kinds with which he worked.

An investigation similar to that of Kondo was carried out a little later (1919) by Krause (7). He described the seeds and seedlings of twenty-four kinds of Brassicae, including, in addition to fourteen of the *B. oleracea* group, samples of swede, swede rape, turnip, turnip rape, and radish. The account which he gives of the seeds and seed coats is in agreement with those of the writers just mentioned, and his chief contribution to the problem is the observation that the seeds of turnip are distinguishable from those of the turnip rape by reference to differences in the histology of their seed coats.

None of the writers mentioned has suggested that any satisfactory diagnostic differences exist between the seeds of the swede turnip and the broad-leaved rape, the two plants with which the present communication is mainly concerned. As regards the seedlings, Kondo did not refer in his paper to any forms of *B. napus,* L. Krause, who made the only other seedling study with which we are acquainted, includes swede turnip and swede rape in his account, but does not state precisely which kind of swede rape he examined, merely describing it as "*B. napus,* Raps," so that it is not necessarily the broad-leaved rape now under consideration. Professor Percival (6), in his text-book of Agricultural Botany, in referring to broad-leaved rape, states: "both seeds and seedlings are identical in appearance with those of swede turnips." The purpose of the

present paper is to show that the seedlings of swede and broad-leaved rape are not identical in appearance, but that it is possible to say which is which while they are still at a very early stage in their development. The practical interest in this question lies mainly in the fact that since both yellow-fleshed swede turnips and broad-leaved rape are grown as farm crops in this country, the seeds of each of these plants are necessarily stocked by seed merchants, some of whom through lack of proper supervision and care in the branding of sacks or containers occasionally find themselves in the position of being unable to say whether a particular lot of seed is swede or rape. In such circumstances it is not surprising that rape seed is from time to time sold as swede seed and *vice versa*, and in neither case is the farmer supplied with what he specifically requires. To add to the difficulty, such a mistake as this is not apparent to the casual observer until the plants are well developed, when it is then too late to repair the damage done, by sowing seeds of the required crop, and much inconvenience and monetary loss necessarily results.

Several instances have occurred in recent years of the finding of such aberrant plants as rape and rape × swede hybrids growing among swede crops in Ireland (5), and in those cases which were investigated it was definitely established that the seed sown was a physiological mixture arising from the cross fertilization of the mother swedes by rape growing in the immediate vicinity. Other cases have been brought to our notice in which whole fields of what should have been swedes have proved to be rape, and the present communication is the result of a study of such irregularities.

With the object of throwing some light on the problem of the distinction between swede and rape plants in the early stages of their growth, several pot cultures were started, using seeds of broad-leaved rape and yellow-fleshed swedes. The seeds were sown in a sterilised compost of sand and loam in eight-inch seed-pans and kept in an unheated greenhouse. Germination was normal, and in approximately fourteen days the first foliage leaves had expanded in each case. It was clearly seen that when the two pots of plants were viewed from above, the colour of the rape seedlings was of a distinctly darker green than that of the swede seedlings, but this feature was less noticeable, and consequently became of less value when individual seedings were examined. It was observed that both sets of seedlings showed a variable amount of hairiness which rendered this character of little diagnostic value. When the individual seedlings were carefully compared at this stage, however, those of rape and swede were found to be different from one another in two characters, viz., the shape of the first foliage leaf and the length of the first internode. These differences, which will now be described, make it possible to distinguish between the seedlings of swede and rape. In the fourteen-day seedling of the swede, the blade of the first foliage leaf is broadly oval, its greatest width being at a point which is usually about midway between the base and the apex. The margin of the leaf is toothed somewhat unevenly, and *the apical tooth in which the midrib terminates is only slightly larger than the teeth adjacent to it;* see Fig. 1, Plate 3. The first foliage leaf of the rape seedling of the same age, on the other hand, is what

may be described as roughly shield-shaped, the lamina being widest above the middle and tapering irregularly downwards. The toothing of the edge is less regular than in the swede, and *the apical tooth is always conspicuously larger than the others;* see Fig. 2, Plate 3.

In examining the swede seedlings eighteen days after the seeds were sown it was noted that *the petioles of the cotyledons and those of the first foliage leaves appeared to arise at approximately the same level on the stem* (Plate 3, Fig. 3), but that in the case of the *rape seedlings a distinct internode varying in length from 2 to 5 mms. was invariably present* (Plate 3, Fig. 4). It must be mentioned in this connection that prior to these examinations all the plants were kept in a well-lighted greenhouse. It was noticed that if swede seedlings were kept for a few days in the laboratory the first internode showed a tendency to elongate slightly. It was only under such conditions of poor illumination that this was ever found to occur. This in no way minimises the value of the relative lengths of the first internodes in distinguishing rape seedlings from those of swede, especially when the feature is considered in conjunction with the shape of the first foliage leaves.

When the foregoing points of difference between swede and rape seedlings were noticed, more extended trials were undertaken in order to put the matter to a critical test. Through the good offices of certain Irish and English seed-raisers supplies of sixteen supposedly different varieties of pedigree yellow-fleshed swede seed were obtained and also supplies of rape seed from ten distinct sources. One hundred seeds from each lot of swede and rape were counted out at random and planted early in the month of June, in sterilised soil in seed-pans which were kept as before in an unheated, well-lighted greenhouse. Germination proceeded normally in every case, and frequent and careful examinations were made of the seedlings which developed. The results obtained corroborated the earlier observations in every case, and proved conclusively that it was possible within a period of twenty days from the sowing of the seeds and, by means of a naked-eye examination, to distinguish the seedlings of ordinary yellow-fleshed swede turnip from those of broad-leaved rape.

To place the identity of the seedlings beyond doubt, typical plants from each lot were carefully removed from the seed-pans and potted in soil in eight-inch flower-pots where they were allowed to continue growth. The transplanted seedlings developed normally, those from the swede lots in due course forming "bulbs," while the others, remaining devoid of any trace of "bulb," produced an abundance of leaves and eventually the lemon yellow (8) flowers of rape.

From an economic point of view the results presented here are of great importance to root-seed raisers and agriculturists generally, since they indicate for the first time a sure and simple means of discriminating between the seedlings of two plants which have hitherto been regarded as indistinguishable in their early stages of growth. Should the necessity arise in the future for establishing the identity of a particular sample of seed, whether swede or rape, the matter may be satisfactorily settled in from fourteen to twenty-one days by sowing the seeds and examining the seedlings produced.

SUMMARY.

A method of distinguishing between the seedlings of the yellow-fleshed swede turnip and these of the broad-leaved rape is described. The characters employed are—

(1) The shape of the first foliage leaf.

(2) The relative lengths of the first internode.

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EXPLANATION OF PLATE.

FIG. 1.—Four first foliage leaves taken at random from seedlings of "Tipperary" Swede, photographed seventeen days after sowing the seeds. $\times 1\frac{1}{3}$.

FIG. 2.—Four first foliage leaves taken at random from seedlings of broad-leaved rape, photographed seventeen days after sowing the seeds. $\times 1\frac{1}{3}$.

FIG. 3.—Upper portion of Swede seedling twenty days after sowing the seed, showing absence of elongation of the first internode. Natural size.

FIG. 4.—Upper portion of rape seedlings twenty days after sowing the seed, showing elongation of the first internode. Natural size.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

No. 12.

THE INFLUENCE OF THE WORK OF SIR WILLIAM ROWAN HAMILTON ON MODERN MATHEMATICAL THOUGHT.

By PROFESSOR A. W. CONWAY, D.Sc., F.R.S.

[Being a Paper read before the Special Bi-Centenary Scientific Meeting of the Royal Dublin Society, June 24th, 1931.]

[Published separately September 21, 1931.]

To anyone knowing Hamilton at the age of thirteen it would have been difficult indeed to form any conjecture as to his future career. For, at that age, he had a good knowledge of thirteen languages. Certainly he got little encouragement, when under the care of his learned uncle, Rev. James Hamilton, to study Mathematics. Yet we find that he presented a paper to the Royal Irish Academy, "On Caustics," at the age of nineteen, when he was yet an undergraduate of Trinity. This paper was referred to a committee, who rejected it, to the great disappointment of the young mathematician, who was beginning to be conscious of his powers. However, two years later the Board of Trinity College, with extraordinary foresight, elected the young undergraduate to be Andrews Professor of Astronomy in the University of Dublin and Royal Astronomer of Ireland. This position he held until his death, at the age of sixty, in 1865.

Hamilton's mathematical work can be divided into four groups, which, arranged in order of time, might be termed Optics, Dynamics, General, and Quaternions. Of the third of these groups we are not in a position to give complete information as yet, for much interesting matter is contained in the great mass of unpublished manuscript stored in the Library of Trinity College. But it will be found that Hamilton's researches in the theory of Partial Differential Equations and in the Expansion of Functions in Series, and his grasp of wave-motion, with its distinction between phase-velocity and group-velocity, showed that he was very much in advance of his time, and will, even at the present day, repay the study of the present generation of scientists.

These earliest researches were on the subject of Geometrical Optics, and show that he, when still a schoolboy, had the germ of the great idea of his Characteristic Function. This paper on Caustics referred to above was discovered amongst his manuscripts, and is printed in Vol. i of his collected works for the first time.[1] Curiously enough it contains no mention of the Characteristic

[1] The Mathematical Works of Sir Wm. R. Hamilton, Vol. i, edited by A. W. Conway and J. L. Synge. Cambridge, the University Press, 1931.

Function, but it contains the foundations of the Theory of Normal Congruences developed long afterwards by Kaummer. Although rejected by the Royal Irish Academy, minute examination of this work by a young undergraduate failed to discover any error, except one which had previously been made by the great Lagrange himself.

If a ray of light goes from a point A to a point B, passing through various media, and if we multiply the length of the ray in each medium by the index of refraction, we get an expression $\Sigma\mu r$ or $\int \mu ds$. This expression has a minimum, or maximum, value for the actual path. Regarding the first point as fixed and the second as variable we get Hamilton's Characteristic Function. By the aid of this and two other closely allied functions Hamilton, in a remarkable series of papers, gave methods of extreme generality for solving all the problems of Geometrical Optics. This prediction of conical refraction in a biaxal crystal, afterwards experimentally verified, was hailed as a mathematical triumph at a time when scientific attention was directed to the discoveries of Arago, Fresnel, and others, in the domain of optics. Although the great discussion between the wave theory of light and the corpuscular theory was coming to an end, for the time being, the former having all the advantage of the struggle, yet Hamilton in his optical work frequently points out the different interpretation which could be put on his formulae. Thus, on the corpuscular theory the index of refraction would represent the velocity of the light particles in the medium, and thus $\Sigma\mu r$ or $\int \mu ds$ would represent what was termed the Action. On the wave theory μ would represent the inverse of the velocity, and $\Sigma\mu r$ or $\int \mu ds$ would be the time taken to pass from A to B, and thus the optical path would be either a path of least action or a path of least time. It was not till 1850, when Foucault was able to find the velocity of light in water or glass, that it was certain that μ was the reciprocal of the velocity of light. Rays of light issuing from a point and passing through a lens or lenses will not in general pass through another point, and the image formed by any combination of lenses will suffer various types of distortion called aberrations. These have been carefully studied and classified by von Seidel and others, and a noteworthy advance was made by Bruns, of Leipzig, who reduced all the problems to the study of one function, or class of functions, called the "Eikonal." The problem of designing a lens-combination from which certain of the aberrations were absent was thus reduced to determining the structure of one function. But amongst the unpublished papers of Hamilton, written twenty years before the investigations of Bruns, was found a complete investigation of these aberrations, and it was clear that Hamilton's Characteristic Function was a very much superior form of the "Eikonal." It is noteworthy that nearly every writer on Practical Optics, especially on the Continent, refers to the great work of Hamilton, but expresses the opinion that the application of such complicated analysis to any practical cases would be impossible, and that Hamilton's own applications of such analysis were never published by him. One reason was, perhaps, that Hamilton's attention was passing from Optics to Dynamics. He saw that the corpuscular interpretation of his Characteristic Function $\int vds$ had an immediate dynamical significance.

The integral $\int mvds$ was called by Maupertuis the "Action," and a dynamical system moves so that the Action is a minimum (or maximum). The use of this in solving definite problems was attempted by Lagrange and others, but Hamilton, by introducing the Principle of Varying Action, put the whole of dynamics on a new basis. In two great papers, published by the Royal Society, he applied his method to the problems which were of interest at the time, the motions of the planets and their perturbations. Jacobi, in Germany, made use of these principles to found the modern sciences of dynamics and of partial differential equations. It has inspired numerous researches in various other branches of science. The Hamiltonian Principle, i.e., $\delta \int (T - W)\, d\tau = 0$ has rendered possible the application of contact transformations to dynamics. In electrodynamics Sir Joseph Larmor and others have used it to obtain the fundamental and other relations of the Hertz-Heaviside type in the form

$$\delta \iiint\int (\kappa E^2 - \mu H^2)\, dxdydzdt = 0.$$

I mention this for the purpose of making a quotation from a letter of Hamilton to H. F. C. Logan of Prior Park: "I think my Characteristic Function of the motion of a system of discontinuous points might be extended to a *plenum* of energies, so as to express the results of their interaction, by the variation of a quadruple integral."

Space will not permit me to speak of the connection between this work of Hamilton and Relativity. I may refer, however, to the name of the Hamiltonian Derivative in that science, and also to the Dynamical Researches in Riemannian Space of Levi-Civita, Professor J. L. Synge, of Trinity College, Dublin, now of Toronto, and of Professor M'Connell, of Trinity College, Dublin.

Hamilton's form of the equations of motion in this canonical form stressed the connection between the conjugate variables p and q, H and t, and not only inspired Jacobi's investigations of conjugate variables, but has inspired the most recent thought on atomic structure.

Hamilton is, perhaps, often thought of as if his sole claim to fame was the discovery of Quaternions. I like to believe that Quaternions will yet have its innings. The concise forms which the Hertz-Heaviside equations and the transformations of the Special Theory of Relativity assume in this calculus seem to show that the possibilities of the quaternion are not yet exhausted. Although outside the theory of numbers, one rarely reads of quaternions at the present day, yet some of his ideas, *e.g.*, "vector" and "scalar," are permanently fixed in the nomenclature of physical science. The various forms of vector Algebra in use at the present day are all degenerate forms of quaternions. The matrix is essential to any student who wishes to understand the most recent advances in the theory of spectra. Let me read the following extract from Cajori's "History of Mathematics," p. 340:—"The originator of matrices is really W. R. Hamilton, but his theory published in his *Lectures on Quaternions* is less general than that of Cayley."

The increasing mass of data with regard to line and band spectra was produced by a great generation of spectroscopists, one of whom, Dr. Adeney,

I am glad to see present to-day. The earlier attempts at orderly arrangements of line spectra of Balmer and Rydberg were continued by Ritz, and an attempt at a theoretical explanation was imperative. The earlier attempts along the lines of the classical electrodynamics met with small success, and the appearance of the Bohr-Sommerfeld-Wilson theory broke new ground. There the whole problem was one of orbital mechanics differing from the Newton-Laplace celestial mechanics by a method of selection of the orbits. This method of selection depended on certain Action constants, and so the whole range of the Hamilton-Jacobi dynamics was brought into action again. I shall content myself with quoting from Sommerfeld's "Atombau," a book which marks the peak point of this theory: "Up to a few years ago it was possible to consider that the methods of Hamilton and Jacobi could be dispensed with for Physics and to regard it as serving only the requirements of the calculus of astronomic perturbations and the interests of mathematics . . . Since 1916 it seems as if Hamilton's method was expressly created for treating the most important problems of physical mechanics."

The Bohr-Sommerfeld theory passed away, unable to assimilate new spectral data, leaving behind, at any rate, valuable descriptions in terms of electrons and energy levels, of atomic phenomena, and the new idea of wave-mechanics started into life. How far the (occasionally) non-commutative variables of Dirac and the matrix variables of Heisenberg were inspired by quaternionic ideas is problematical. But the third method of attack, that of Schrödinger and de Broglie, is of no doubtful provenance. Let me quote from an epoch-making memoir of Schrödinger, Annaler der Physik, 1926: "The inner connection between Hamilton's theory and the process of wave-propagation is anything but a new idea. It was not only well known to Hamilton, but it also served him as the starting point for his theory of mechanics . . . Unfortunately, this powerful and momentous conception of Hamilton is deprived in most modern reproductions of its beautiful raiment as a superfluous accessory."

Throughout the centuries the battle between wave and corpuscular theories persists. Maupertuis, Fermat, Huyghens, Newton, Laplace, and a host of others, have carried on the strife which to-day is less decided than ever, for a wave of light has, from some points of view, the properties of a particle, the light quantum, and an electron can sometimes, with advantage, be regarded as that mysterious object, a wave packet. In its essentials it is a fight between optical and dynamical theory. It is not remarkable that Hamilton's early work was divided between these two subjects, and is it merely a coincidence, or is it a prophecy, that he should have written the following letter to his uncle in 1834?: "I content myself, as yet, with offering one science to Ireland and another to England, holding out with each a hope of their future union, in some imagined consummation."[1]

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[1]Life of Sir Wm. Rowan Hamilton, Vol. ii, by R. P. Graves, p. 74, Dublin University Press, 1885.

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